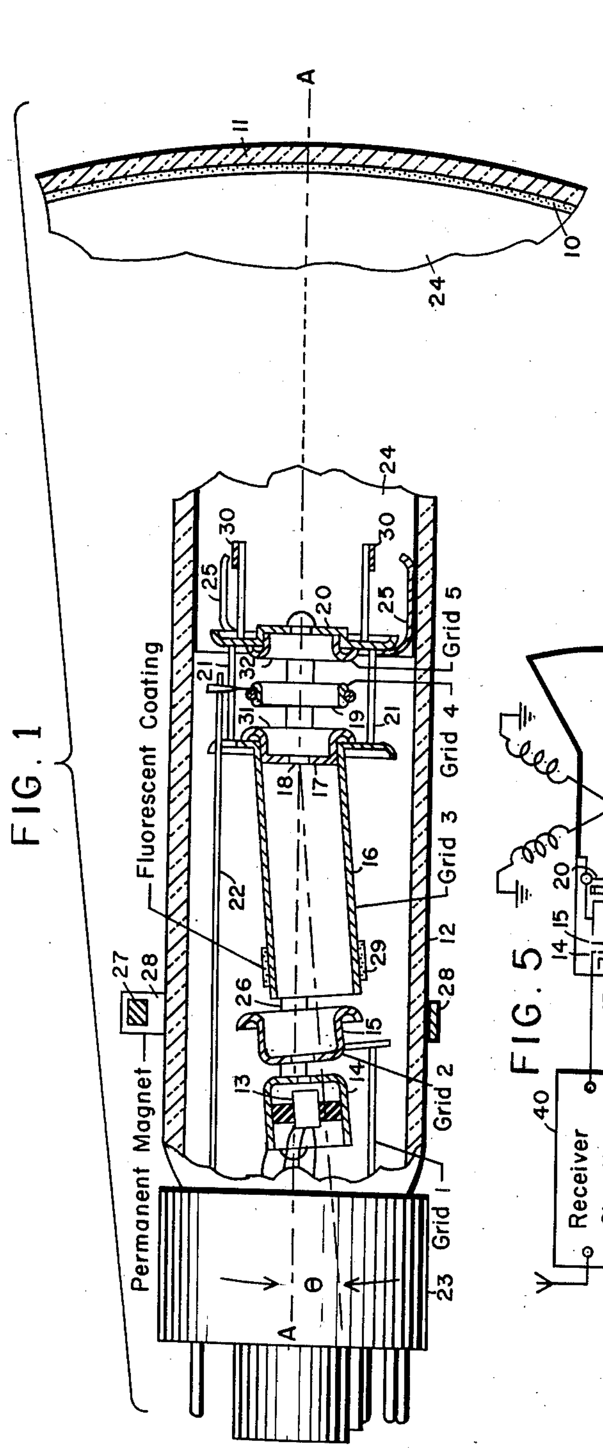
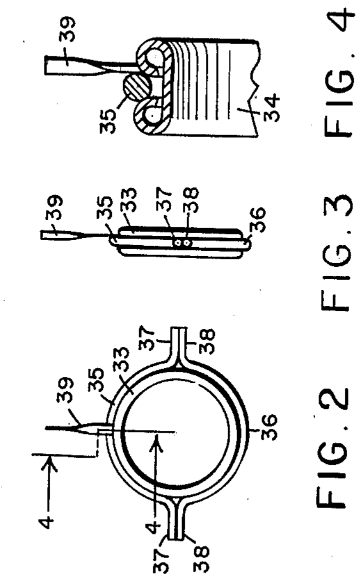
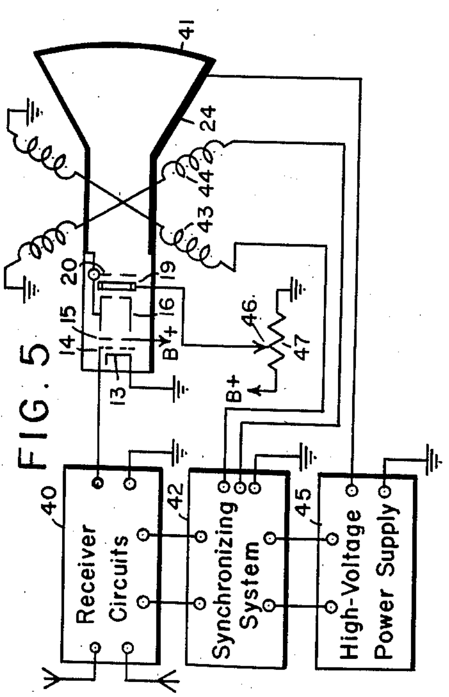
Jan. 27, 1953 H. H. BOEING 2,627,047

CATHODE-RAY TUBE ELECTRODE

Filed July 6, 1951







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Patented Jan. 27, 1953

2,627,047

UNITED STATES PATENT OFFICE

2,627,047

CATHODE-RAY TUBE ELECTRODE

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Application July 6, 1951, Serial No. 235,448

3 Claims. (Cl. 313—285)

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This invention relates to image-reproducing devices and more particularly to electrostatically focused cathode-ray tubes for use as picture-reproducing devices in television receivers and the like.

In the copending application of Constantin S. Szegho, Serial No. 229,013, filed May 31, 1951, for "Image-Reproducing Device" and assigned to the present assignee, there is disclosed and claimed a novel cathode-ray tube employing an ion-trap type electron gun in conjunction with a unipotential electrostatic focusing system which requires no operating potential between the B-supply potential of the associated receiver apparatus and the final anode voltage. The unipotential electrostatic focusing system comprises three electrodes, the outermost two of which are operated at final anode voltage, while the intermediate one is operated at or near cathode potential to provide the desired electrostatic field distribution comprising convergent and divergent lens components and having a net convergent effect on the electron beam. Because optimum beam focus is required for some operating potential of the intermediate or lens electrode between ground potential and the B-supply voltage of the associated receiver apparatus, and because this range of operating potentials for the lens electrode is extremely narrow with respect to the final anode voltage, the electrode dimensions and spacings are quite critical and require the maintenance of stringent manufacturing tolerances. In view of the relatively close electrode spacings and the high potential gradients involved, occasional undesirable arcing and field emission may be encountered.

It is an important object of the present invention to alleviate this undesirable condition by providing a new and improved construction for the low-potential lens electrode.

It is a further object of the invention to provide such a new and improved lens electrode which is simple and inexpensive to construct yet adapted to the maintenance of stringent manufacturing tolerances.

These and other objects are accomplished in accordance with the present invention by employing a lens electrode comprising a ring member having a cylindrical central portion rounded at each end. The ring member is peripherally clamped between a pair of opposed semicircular wire members having joined outwardly extending end portions which serve as support tabs for the lens electrode.

The features of the present invention which

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are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood, however, by reference to the following description taken in connection with the accompanying drawing, in the several figures of which like reference numerals indicate like elements, and in which;

Figure 1 is a fragmentary side elevation, partly in cross-section and partly cut away, of an image-reproducing device embodying a lens electrode constructed in accordance with the present invention;

Figure 2 is a plan view of a lens electrode constructed in accordance with the invention;

Figure 3 is a side elevation of the lens electrode of Figure 2;

Figure 4 is a partial cross-section taken along the line **4**—**4** of Figure 3; and

Figure 5 is a schematic diagram of a television receiver embodying the image-reproducing device of Figure 1.

The image-reproducing device of Figure 1 comprises a fluorescent screen **10** affixed to the glass target portion **11** of a cathode-ray tube envelope which also comprises a glass neck portion **12** enclosing an electron gun and an electrostatic focusing system. The electron gun comprises a cathode **13**, a control electrode **14**, and first and second accelerating electrodes **15** and **16** respectively. A diaphragm **17** having a central aperture **18** is disposed across the outlet end of second accelerating electrode **16**, and aperture **18** is symmetrically centered with respect to the tube axis A—A perpendicular to the center of the fluorescent screen **10**. Second accelerating electrode **16** is laterally offset from first accelerating electrode **15** to provide a transverse electrostatic-deflection field in the region between these two electrodes, and the entire electron gun structure is tilted with respect to the tube axis A—A by an angle θ.

An electrostatic focusing system of the unipotential lens type is disposed between the electron gun and the fluorescent screen. The focusing system comprises the outlet end of second accelerating electrode **16** including diaphragm **17**, a lens electrode **19**, and an additional electrode **20** which are all coaxially mounted with respect to the tube axis A—A. Diaphragm **17** and additional electrode **20** are maintained at a common operating potential by means of connecting strips **21**, while lens electrode **19** is provided with a separate lead **22** extending through the base **23** of the tube. Additional electrode **20** is further maintained at a common potential with a conductive coating 24, of colloidal graphite such as aquadag or the like, on the inner wall of the tube envelope, by means of metal spacer springs 25. Conductive coating 24 extends toward the base only as far as electrode 20 to avoid undesirable spark discharge between that coating and lens electrode 19, and lead 22 may be provided with an insulating glass bead (not shown) to prevent spark discharge to electrode 16.

For convenience, electrodes 14, 15, 16, 19 and 20 may be termed "grids" and may be designated by number starting with control electrode 14 as the first grid and progressing in the direction of beam travel to additional electrode 20 which is the fifth grid. All five grids are supported in predetermined mutually spaced relation by means of a pair of glass pillars 26, of which only one is shown, in a manner which will be apparent to those skilled in the art. Separate leads for grids 1, 2 and 4 extend through the base 23 of the tube, as do the supply leads for the cathode 13 and its associated heater element (not shown). Operating voltage for the conductive coating 24, and therefore for the third and fifth grids, may be supplied by means of a conventional contact button if the envelope is of the all-glass type, or directly to the metal cone member if the tube is of the glass-metal variety.

An external permanent magnet 27, supported in a spring clamp 28 which fits snugly around the neck of the tube and is movable both axially and rotationally, is provided to develop a magnetic field within the tube to provide separation of the negative ions from the electron beam. Moreover, a fluorescent coating 29 on the outer surface of the second accelerating electrode 16 (grid 3) is provided for facilitating alignment of ion-trap beam-bender magnet 27.

The tube is evacuated, sealed and based in accordance with well-known procedures which require no further explanation, and suitable getters 30 are supported from grid 5 to absorb residual gases after evacuation.

In operation, a mixed beam of electrons and negative ions originating at cathode 13 is projected through the aperture in first accelerating electrode 15. When the mixed beam emerges from grid 2, it encounters an electrostatic field having a transverse component due to the lateral offset of grid 3 with respect to grid 2. Consequently, electrons and ions are both deflected upwardly in the view of Figure 1. The magnetic field imposed by beam-bender magnet 27 serves to deflect the electrons in a downward direction as viewed in Figure 1 without substantially affecting the path taken by the negative ions. Thus, when beam-bender magnet 27 is accurately adjusted, the beam of electrons is projected centrally through aperture 18 of diaphragm 17 in a direction along the tube axis A—A, while the negative ions are intercepted by the metallic portions of grid 3 and diaphragm 17. The ion-trap mechanism is disclosed and claimed in the copending application of Willis E. Phillips et al., Serial No. 156,745, filed April 19, 1950, for "Electron Gun for Cathode-Ray Tubes", now U. S. Patent No. 2,596,508 issued May 13, 1952, and assigned to the present assignee.

The axially directed electron beam is subjected to the focusing action of the electrostatic fields produced by the outlet end of second accelerating electrode 16 including diaphragm 17, lens electrode 19 and the fifth grid 20 which together constitute a unipotential electrostatic focusing lens system. The general construction and operation of lenses of this type are well understood by those skilled in the art as indicated by an article entitled "Measured Properties of Strong 'Unipotential' Electron Lenses" by G. Liebmann, Proceedings of the Physical Society, section B, volume 62, part 4, pages 213-228 (April 1, 1949).

The required operating potential difference between the lens electrode (grid 4) and the other electrodes of the focusing system (grids 3 and 5) is determined by the dimensions of and the spacing between the electrodes constituting the unipotential lens. Although the relationships are not necessarily linear, the required focusing potential difference varies directly with the length and inversely with the diameter of grid 4, and inversely with the separation between grid 4 and grids 3 and 5. Certain limitations on these parameters are imposed by practical considerations; if the diameter of grid 4 is made too small, excessive spherical aberration is encountered and if the separation between grids 3 and 4 is made too great, the deflecting influence exerted by the asymmetrical electrostatic field established between lead wire 22 and grid 3 becomes objectionable.

Unipotential electrostatic lens systems have previously been employed in cathode-ray tubes. Such lens systems have been found quite satisfactory and readily adaptable to mass production techniques when the electron gun and the focusing system are coaxial and the path of the beam is restricted to the tube axis during its entire progress from the cathode through the focusing system. However, according to present commercial practice, nearly all television picture tubes are provided with an ion-trap mechanism of one sort or another for removing negative ions from the electron beam in order to avoid deterioration of the fluorescent screen. Such types of ion-trap arrangements as are commonly employed provide ion separation by subjecting the mixed beam to opposed electrostatic and magnetic fields; both electrons and ions are transversely deflected by the electrostatic field, while the electrons only are substantially deflected in the opposite direction by the impressed magnetic field. It is apparent that the practical requirement for ion trapping results in a displacement of the electron beam from the tube axis, and it is necessary that the beam be directed to the axis before it enters the focusing system. The accuracy with which this is accomplished is of importance when magnetic focusing is employed or when a unipotential electrostatic lens system is employed with a focusing voltage source which may be varied over a relatively wide range, but slight misalignment may be compensated by varying the focusing voltage. However, the ion trap alignment becomes much more critical when satisfactory operation of the electrostatic focusing system is required within a narrow focusing voltage range between cathode potential and the B-supply voltage of the associated apparatus, owing to the increased strength of the individual lens components constituting the unipotential focusing system.

In general, if the electron beam is inaccurately centered or approaches the focusing system in an angular manner, multiplicity of focus is encountered. The most troublesome form in which this manifests itself is that of astigmatism and/or coma. In order to obtain focusing comparable with that provided by magnetic focusing systems, while operating the lens electrode at or near cathode potential, it has been found essential that the electron beam be centrally directed along the axis in its passage through the focusing system. In other words, the ion trap must be precisely adjusted for satisfactory focusing with a low-potential electrostatic lens system. Such precise alignment of the ion trap is facilitated by providing a fluorescent coating 29 on the outer wall of second accelerating electrode 16. This fluorescent coating serves as an ion-trap adjustment indicator; in practice, permanent magnet 27 is moved both axially and rotationally until the glow from fluorescent coating 29 is reduced to a minimum, thus indicating precise ion trap alignment. The fluorescent coating must of course be so situated that it is excited into fluorescence whenever the electron beam is entirely or partially intercepted by diaphragm 17, and the fluorescent glow must be visible, either directly or by reflection, through the transparent neck portion 12 of the tube envelope. Other possible locations for fluorescent coating 29 include the inner wall of neck portion 12 near the space between grids 2 and 3, the inner surface of diaphragm 17, and the surface of diaphragm 20 facing the cathode. The ion-trap indicator is described and claimed in the copending applications of Constantin S. Szegho, Serial No. 134,725, filed December 23, 1949, now U. S. Patent No. 2,564,737, issued August 21, 1951, and of Constantin S. Szegho et al., Serial No. 162,906, filed May 19, 1950, both entitled "Cathode-Ray Tube", now U. S. Patent No. 2,565,533, issued August 28, 1951, and both assigned to the present assignee.

In order to obtain satisfactory focusing with the system shown in Figure 1, it is necessary to maintain rather stringent manufacturing tolerances with respect to the dimensions and spacings of the several electrodes constituting the focusing system. In addition, since grid 4 is to be operated at a potential substantially equal to that of the cathode, extremely high voltage gradients are produced between grid 4 and grids 3 and 5. In order to avoid undesirable corona effects and field emission, grids 3 and 5 are each provided with corona rings 31 and 32 in the form of rolled flanges of stainless steel or the like which are welded or otherwise secured to the respective electrodes.

In accordance with the present invention, and as illustrated in Figures 2, 3 and 4, lens electrode 19 (grid 4) comprises a circular ring member 33 having a cylindrical central portion 34 doubled back at each end to define an outer peripheral depression or ridge in which are seated a pair of opposed semicircular wire members 35 and 36 having outwardly extending end portions 37 and 38 which are joined as by welding or the like to serve as support tabs for the electrode. In other words, ring member 33, which is the effective portion of the electrode, is peripherally clamped between opposed semicircular wire members 35 and 36, and the outwardly extending ends 37 and 38 of wire members 35 and 36 are joined to furnish support tabs which may be fused into the common glass support pillars 26 (Figure 1). A thin metal ribbon 39 is connected to wire member 35 to serve as a connection between lead 22 (Figure 1) and the focusing electrode.

The grid 4 construction of the present invention permits the maintenance of a minimum mechanical contact area between the glass pillars and the lens electrode; moreover, the improved construction insures that the length of the leakage path across the glass support pillars is a maximum for the predetermined electrode spacing, since the support tabs 37, 38 are longitudinally centered with respect to the effective electrode surface constituted by ring member 33. Arcing and field emission are held to a minimum since the construction is free of sharp edges and corners. Moreover, the electrode construction is simple and economical and well adapted to quantity production on a commercial basis.

The corona rings 31 and 32 also perform an additional function in facilitating the maintenance of the required close manufacturing tolerances by mechanically reinforcing the circular flanges to which they are attached against warping or bending during the assembly of the electrode system. The electrodes are assembled by means of accurately constructed jigs and are all rigidly supported by means of opposed common glass pillars 26, the gun assembly properly oriented in the tube neck by means of other jigs in the usual manner. It has been found that these precautions suffice to insure satisfactory operation of the completed structure, any small deviations in dimensions and spacings being readily compensated by adjustment of the ion-trap magnet 27.

As compared with the somewhat similar constructions now employed in magnetically focused television picture tubes, the electron gun of the tube of Figure 1 has been modified in two further structural respects. In the first place, the angle θ by which the entire gun is tilted with respect to the tube axis A—A is reduced from about 6 degrees to about 4¾ degrees, and the amount of lateral offset of grid 3 with respect to grid 2 is reduced from 1.9 mm. to 1.6 mm. In the second place, the length of the tubular portion of grid 3 is reduced from about 38 millimeters to about 30 millimeters.

These two parameters influence the performance of the electrostatic focusing system in the following manner. In order to obtain satisfactory focusing with the reduced focusing-voltage range, it is desirable to make the electron beam more nearly parallel as it enters the focusing system. This may be accomplished by locating the unipotential lens system nearer to the cathode and thereby decreasing its focal length; for this reason grid 3 is shortened. However, it is not possible to shorten grid 3 indefinitely because a certain minimum length is required to insure ion trapping at normal operating voltages. To compensate for the impaired performance of the ion trap occasioned by shortening grid 3, the amount of lateral offset between grids 2 and 3 and the angle θ by which the entire electron gun is tilted with respect to the tube axis A—A may each be increased; however, increasing the angle of gun tilt results in an increase in the angle at which the beam enters the focusing system, resulting in greater astigmatism and/or coma, so that from this point of view the angle of gun tilt should be made as small as possible consistent with the requirement for ion-trapping with a single beam-bender magnet. The condition represented by the relationships set forth in the preceding paragraph has been found to provide good focusing while retaining ion trapping at reasonable operating voltages. In this connection, it is observed that the particular type of offset ion trap employed in the tube of Figure 1 has the important advantage over other types of ion-trap gun, such as that employing coaxial electrodes with a slanted aperture between grids 2 and 3, that a greater angle of gun tilt may be employed for a given amount of lens distortion since the cathode is closer to the tube axis. Moreover, the offset type of ion trap is free of the characteristic elliptical distortion associated with the coaxial slanted-aperture type.

For best results, it has been found that the apertures in grids 1, 2, 3 and 5 should be in marginally overlapping alignment in a direction parallel to the tube axis A—A. In other words, all of these apertures should intercept an imaginary straight line parallel to reference axis A—A, and the apertures in grids 1 and 2 should intercept that line asymmetrically. Fulfillment of this condition is dependent upon the angle θ by which the entire electron gun is tilted with respect to the tube axis, and also upon the length of the electron gun from the cathode to aperture 18 in diaphragm 17. If the angle θ and/or the length of the gun is increased to such an extent that the apertures in grids 1, 2, 3 and 5 are no longer in marginally overlapping alignment in a direction parallel to the tube axis, increased multiplicity of focus is encountered, and the performance of the focusing system is inferior. On the other hand, if the angle θ is decreased so that the apertures are in complete coaxial alignment, ion trapping may no longer be conveniently accomplished with a single beam-bender magnet.

In the television receiver schematically illustrated in Figure 5, incoming composite television signals are received and separated into video-signal components and synchronizing-signal components by means of conventional receiver circuits 40 which may include a radio-frequency amplifier, an oscillator-converter, an intermediate-frequency amplifier, a video detector, a video amplifier and a synchronizing-signal separator, as well as suitable circuits for reproducing the sound portion of the received signal. The detected composite video signal from receiver circuits 40 is applied between the control electrode 14 and the grounded cathode 13 of an image-reproducing device 41 of the type shown in Figure 1. Synchronizing-signal components of the detected composite video signal are employed to drive a synchronizing system 42 of conventional construction which supplies the line-frequency and field-frequency deflection coils 43 and 44 with suitable scanning currents to control the scansions of the cathode-ray beam of device 41. A high-voltage power supply 45, which may also be of conventional construction, is employed to provide a suitable high operating voltage for the conductive coating 24 to which grids 3 and 5 are internally connected. Lens electrode 19 (grid 4) is connected to a variable tap 46 associated with a potentiometer resistor 47 connected between the receiver D. C. voltage supply source, conventionally designated B+, and ground. With the tube construction shown and described in connection with Figure 1, optimum focus of the cathode-ray beam is achieved when the minimum glow of fluorescent coating 29 indicates precise ion-trap alignment and when the lens electrode 19 is operated at a potential substantially equal to that of the cathode 13.

Merely by way of illustration and in no sense by way of limitation, it may be desirable to tabulate certain critical dimensional relationships in an operative embodiment of the invention constructed in the manner shown and described in connection with Figure 1. Satisfactory results have been obtained with a tube of the type shown

in Figure 1 having the following dimensional relationships:

Angle θ of gun tilt	4° 45′
Length of grid 3	30 millimeters
Lateral offset of grid 3 with respect to grid 2	.063 inch
Longitudinal spacing between grid 2 and grid 3	.080 inch
Diameter of aperture in grid 1	.040 inch
Diameter of aperture in grid 2	.075 inch
Diameter of aperture 18	.100 inch
Diameter of aperture in grid 5	.100 inch
Inner diameter of grid 4	.500 inch
Inner diameter of corona rings 31 and 32	.470 inch
Axial length of grid 4	.125 inch
Axial spacing between grid 3 and grid 4	.100 inch
Axial spacing between grid 4 and grid 5	.100 inch

The dimensions of grids 3, 4 and 5 and the spacings between these electrodes are quite critical if optimum focusing conditions are to be achieved with a focusing voltage substantially equal to that of the cathode. It has been determined that uniform results may be obtained by maintaining these critical dimensional relationships within a manufacturing tolerance of plus .001 inch, minus .000 inch.

While the novel electrode construction of the present invention has been described as having particular advantages in a unipotential electrostatic focusing lens system of the low-potential type in which the lens electrode is operated at a potential equal to 5% or less of the final anode voltage, it is apparent that the invention is of general application in other types of unipotential electrostatic focusing arrangements. Moreover, the invention may be employed in a cathode-ray tube having any type of electron gun, with or without provision for ion trapping.

While a particular embodiment of the present invention has been shown and described, it is apparent that various changes and modifications may be made, and it is therefore contemplated in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. In a unipotential electrostatic focusing lens system for a cathode-ray tube, an electrode comprising: a ring member having a cylindrical central portion rounded at each end; and a pair of opposed semicircular wire members peripherally clamping said ring member and having joined outwardly extending end portions constituting support tabs for said electrode.

2. In a unipotential electrostatic focusing lens system for a cathode-ray tube, an electrode comprising: a circular ring member having a cylindrical central portion outwardly doubled back at each end to define an outer peripheral depression; and a pair of opposed semicircular wire members seated in said peripheral depression and having joined outwardly extending end portions constituting support tabs for said electrode.

3. In a unipotential electrostatic focusing lens system for a cathode-ray tube, an electrode comprising: a circular ring member having a cylindrical central portion outwardly doubled back at each end to define an outer peripheral depression; and at least one semicircular wire member seated in said peripheral depression and having

outwardly extending end portions constituting support tabs for said electrode.

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